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East-directed subduction, erosion of overriding continental crust and the genesis of Western Mediterranean lamproites

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Small intrusive and extrusive bodies of lamproitic rocks are scattered along the Alpine collision front in the Western Mediterranean area. They occur in the Western Alps (ca. 30 Ma), Corsica (ca. 14 Ma), Betic Cordillera (ca. 6-8 Ma) and Tuscany (ca. 0.9-4.1 Ma), and are spatially and temporally associated with calcalkaline and shoshonitic rocks.

The Western Mediterranean lamproites (WML) are SiO2-rich lamproites, characterized by relatively low CaO, Al2O3 and Na2O, and high K2O/Al2O3. They also show high MgO, Ni and Cr denoting a mantle origin.

The WML exhibit remarkable similarities in terms of incompatible element abundances and radiogenic isotope compositions. They all display strongly fractionated incompatible element patterns with high enrichments in K, Cs, Rb, Th, U, Pb and LREE, and depletion in Ta, Nb, and Ti, features distinctive of magmas originated along converging plate margins where recycling of crustal material in the mantle takes place. Differently from typical arc-related magmas, the WML display characteristic Ba and Sr negative anomalies and Th positive anomalies in primordial mantle-normalized element diagrams, features that are frequently observed in upper crustal rocks of pelitic composition. WML display REE patterns with high enrichments in LREE (values up to 600 times chondritic values) relative to HREE (values up to 15 times chondritc values), small Eu negative anomalies and similar enrichment values for LREE and HRRE respectively.

The WML display overlapping Sr-Nd-Pb isotopic compositions with variable high Sr isotopic ratios in the range 0.712-0.723, low 143Nd/144Nd values in the range 0.5120-0.5122 and moderately radiogenic Pb isotopic ratios that fall in an narrow range (206Pb/204Pb = 18.61-18.86).

The range of radiogenic isotope ratio values and the incompatible element abundances of the WML require mantle sources profoundly metasomatized by upper crustal material. Moreover, the remarkably uniform petrological, geochemical and isotopic compositions of WML strongly call for a common type of contaminant and the same geodynamic context for source contamination processes.

One of the most striking features observed for the WML is their Pb-Sr-Nd isotopic composition, that reveals highly variable Sr isotopic ratios but values for the Pb isotopic ratios that fall in a very restricted range. Thus, a contaminant able to imprint this particular isotopic signature must have been ubiquitously involved in the genesis of the WML.

Tuscan anatectic rocks and Carboniferous metasediments (feasible source rocks for the anatectic melts) and Permian granites from the Southern Alps (e.g., granites of the “Serie dei Laghi”, granitoid rocks of Cima d’Asta and Bressanone-Chiusa) exhibit remarkable similarities in terms of Sr-Nd-Pb isotopic compositions with the WML and in particular have 206Pb/204Pb values that fall in the same narrow range as WML. Moreover the alpine Permian granites display incompatible trace element patterns that resemble those of the WML, showing some characteristic features like Ba and Sr negative anomalies in primordial mantle-normalized element diagrams.

The geochemical and isotopic compositions of Tuscan Carboniferous metasediments and alpine Permian granites are a proxy for the composition of the upper continental crust of the northern African plate margin. Given the notable geochemical and isotopical correspondence between WML and Hercynian African crust lithologies, in particular the striking overlap in Pb isotopic compositions, we suggest that the mantle source of the WML was thoroughly contaminated by upper crustal rocks derived from the Paleoafrican continental margin.

The occurrence of lamproitic magmatism along the Alpine collision front suggests that mantle contamination occurred during east-verging Cretaceous-Oligocene subduction of the European plate beneath the Paleoafrican continental margin. We suggest that crustal material was eroded from the overriding continental plate by the low-angle subducting European slab and added to the mantle. The relatively low Ba/Th, U/Th and Sr/Nd ratios, and relatively high HFSE abundances of the WML, indicate that mantle metasomatism via aqueous fluids was unlikely and support metasomatic processes implying direct addition of bulk crustal material to the mantle source and/or crustal rock partial melts percolating the overlaying mantle.

Mantle melting and generation of lamproites took place after the Europe-Africa continental collision, during the post-orogenic collapse of the Alps and diachronous opening of Western Mediterranean basins.